Title: Change to --- A Multichannel Filter-Based Handheld Ultra Wideband Communications ---

Specification:

Page 1, in the Title:

Multichannel Filter For Outdoor Handheld Ultra Wideband Communications

--- Examiner indicated that in the Title "outdor" should be changed to "outdoor." However, in the application, Applicant did use "outdoor" in the Title. Applicant further finds that the word "outdor" was used by USPTO in the filing receipt on October 01, 2003. Therefore, the application title has been changed to:

A Multichannel Filter-Based Handheld Ultra Wideband Communications

Page 1, in the background section, the first paragraph, replace with the following new paragraph:

--- This invention is generally relative to wireless outdoor handheld ultra wideband communications. ~~for outdoor operation.~~

Page 1, in the background section, the second paragraph, replace with the following new paragraph:

--- On April 22, 2002, U.S. Federal Communications Commission (FCC) released the revision of Part 15 of the Commission's rules regarding ultra-wideband (UWB) transmission systems to permit the marketing and operation of certain types of new products incorporating UWB technology. With appropriate technology, UWB device can operate using spectrum occupied by existing radio service without causing interference, thereby permitting ~~scare~~ scarce spectrum resources to be used more efficiently. It has been known that UWB technology offers significant benefits for Government, public safety, businesses and consumers under an unlicensed basis of operation spectrum.

Page 1, in the background section, the third paragraph (extends to page 2), replace with the following new paragraph:

--- UWB ~~device~~ <u>devices</u> can be classified in three types based on the operating restrictions: (1) imaging system including ground penetrating radars and wall, through-wall, surveillance, and medical imaging device, (2) vehicular radar systems, and (3) communications and measurement systems. In general, FCC is adapting unwanted emission limits for UWB ~~device~~ <u>devices</u> that are significantly more stringent than those imposed on other Part 15 devices. In other words, FCC limits outdoor use of UWB ~~device~~ <u>devices</u> to imaging systems, vehicular radar systems and handheld devices. Limiting the frequency band, which is based on the −10 dB bandwidth of the UWB emission, within certain UWB products will be permitted to operate.

Page 2, in the background section, the third paragraph (extends to page 3), replace with the following new paragraph:

--- FCC proposed to define a UWB device as any device where the fractional bandwidth is greater than 0.25 based on the formula as follows:

$$FB = 2\left(\frac{f_H - f_L}{f_H + f_L}\right), \qquad (1)$$

where f_H is the upper frequency of the −10 dB emission point and f_L is the lower frequency of the −10 dB emission point. The center frequency of the UWB transmission is defined as the average of the upper and lower −10 dB points[[.]] ~~That is~~ <u>as follows:</u>

$$\cancel{F_C = \frac{f_H - f_L}{2}. \qquad (2)}$$

$$F_C = \frac{f_H + f_L}{2}. \qquad (2)$$

In addition, a minimum frequency bandwidth of 500 MHz must be used for an UWB device regardless of center frequency.

Page 3, in the background section, the second paragraph, replace with the following new paragraph:

--- Given an entire frequency bandwidth of 7.5 GHz (3.1-10.6 GHz), it is difficult to design [[the]] a transmitter and/or receiver device for a single UWB signal that occupies the entire frequency bandwidth from 3.1 GHz to 10.6 GHz directly. This is because we need to have a very-high speed A/D and D/A converter as well as a high-speed circuit[[s]] and digital signal processor[[s]] to operate [[the]] an UWB device for the wireless communications. As a result, the cost of ~~such a~~ the UWB device could be ~~very~~ expense. In addition, interference between the UWB and other devices, such as a WLAN 802.11a device, can [[be]] ~~occurred~~ occur because the WLAN 802.11a device operates in the lower frequency range from 5.15 GHz to 5.35 GHz or in the upper frequency range from 5.725 GHz to 5.825 GHz. Moreover, the UWB device may not be able to ~~transmission of~~ transmit data with scalability.

Page 4, in the background section, the first paragraph, replace with the following new paragraph:

--- Due to the proliferation of 7.5 GHz UWB for wireless broadband communications, it would be desirable to have a new technology of developing one multichannel UWB solution with a scalability of the transmission data rate, which not only [[to]] ~~reduce~~ reduces the interference with [[the]] WLAN 802.11a devices ~~and to transmit and receive the transmission data rate with scalability as well as~~ but also has a lower ~~reduce the~~ cost for an outdoor handheld UWB transceiver. The multichannel UWB solution highly depends on a multichannel filter, which must meet the FCC request of the outdoor emission limitation, to

provide the multichannel-based multi-carrier modulation. Therefore, in this embodiment, the multichannel filter-based outdoor handheld ultra wideband communications is invented for wireless broadband communications.

Page 4, in the background section, the second paragraph, replace with the following new paragraph:

--- Thus, there is a continuing need of the multichannel filter-based outdoor handheld UWB transceivers that enables a user to transmit the data rate with programmability and scalability and avoid the interference with WLAN 802.11a devices.

Page 4, in the brief description of the drawings, the last two paragraphs, replace with the following new paragraphs:

--- FIG. 1 shows a block diagram of ~~showing~~ one embodiment of a multichannel filter-based outdoor handheld UWB communication system in accordance with the present invention.

--- FIG. 2 is a block diagram of ~~showing~~ a multichannel filter-based UWB transmitter of outdoor handheld UWB transceiver according to some embodiments.

Page 5, in the brief description of the drawings, the first paragraph, replace with the following new paragraphs:

--- FIG. 3 is a block diagram of ~~showing~~ a multichannel filter-based UWB receiver of outdoor handheld UWB transceiver according to some embodiments.

Page 5, in the brief description of the drawings, the fifth paragraph, replace with the following new paragraphs:

--- FIG. 7 is a block diagram of ~~showing~~ a digital cascaded FIR filter including a digital multiband FIR lowpass shaping filter and digital FIR rejected lowpass filter according to one embodiment.

Page 6, in the brief description of the drawings, the fifth paragraph, replace with the following new paragraphs:

--- FIG. 15 is a frequency spectrum including 10-multichannel spectrums (without the ~~forth~~ <u>fourth</u> channel) and the outdoor FCC emission limit according to some embodiments.

Page 8, in the detailed description section, the second paragraph, replace with the following new paragraph:

--- The handheld UWB communication transceiver 100 can transmit and/or receive the UWB signals by using one single channel and/or up to 11-multichannel. Each channel has a frequency bandwidth of 650 MHz. The UWB transceiver 100 can transmit 40.625 Msps with a single channel. A total of 11-multichannel can allow the UWB transceiver 100 to transmit 446.875 Msps in ~~parallels.~~ <u>parallel.</u> With 16 PN spread sequence codes for each symbol, the UWB transceiver 100 can transmit 650 Mcps within each channel. As a result, the handheld UWB communication transceiver 100 can transmit and/or the chip data rate up to 7.150 Gcps for the outdoor operation.

Page 8, in the detailed description section, the third paragraph (extends to page 9), replace with the following new paragraph:

--- FIG. 2 is a block diagram of ~~showing~~ <u>a</u> multichannel filter-based UWB transmitter 200 of the outdoor handheld UWB transceiver according to some embodiments. The UWB transmitter 200 receives user data bits 210

with information data rate of 223.4375 Mbps. The information data bits 210 are passed through a 1/2-rate convolution encoder 212 that may produce a double data rate of 446.875 Msps by adding redundancy bits. The symbol data is then interleaved by using a block interleaver 214. Thus, the output symbols of the block interleaver 214 are formed the 11-multichannel UWB signal by using a multichannel PN sequence mapping 218. Each channel has the symbol data rate of 40.625 Msps. The multichannel PN sequence mapping 218 is to perform spreading for each channel symbol data with 16 orthogonal spread sequence chips and to produce 650 Mcps for each channel under a multichannel control 230. A PN sequence look-up table 216 provides the unique orthogonal sequences for each channel spreading. Then each channel symbol data are sequentially passed through a digital FIR shaping filter system 220 to limit the frequency bandwidth of UWB signal with 650 MHz for each channel transmission. Each channel signal is then passed through a D/A converter 222. The output chip data of each channel from the D/A converter 222 is thus modulated with a multi-carrier by using a multichannel based multi-carrier modulator 224. Then, the output analog signals of the multichannel-based multi-carrier modulator 224 are passed to the power amplifier (PA) 226 through an antenna into air.

Page 9, in the detailed description section, the second paragraph (extends to page 10), replace with the following new paragraph:

--- FIG. 3 is a block diagram of ~~showing~~ a multichannel filter-based outdoor handheld UWB receiver 300 according to some embodiments. A low noise amplifier (LNA) 310 that is connected with a multichannel-based multi-carrier down converter 312 receives the UWB signals from an antenna. The output of the LNA 310 is passed through the multichannel-based multi-carrier down converter 312 to produce the baseband signal for an A/D converter 314. A multichannel control 320 and synchronization

and time control 318 restrain the multichannel-based multi-carrier down converter 312. The bandlimited UWB analog signals are then sampled and quantized by using the A/D converter 314, with the sampling rate at ≥ 650 MHz. The digital signals of the output of the A/D converter 314 are filtered by using a digital FIR receiver lowpass filter 316 to remove the out of band signals with controlling from the synchronization and time control 318. The output data from the digital FIR receiver lowpass filter 316 is used for a rake receiver 324. The channel estimator 322 is used to estimate the channel phase and frequency that are passed into the rake receiver 324. The rake receiver 324 calculates the correlation between the received UWB signals and the channel spread sequences, which are provided by using the PN sequence look-up table 332, and performs coherent combination. The output of the rake receiver 324 is passed to an equalizer 326, which also receives the information from the channel estimator 322, to eliminate inter-symbol interference (ISI) and inter-channel interference (ICI). Then, the output of the equalizer 326 produces the signals for a de-spreading of PN sequence and de-mapping 328 to form the UWB signals of symbol rate at 446.875 Msps. The symbol data is de-interleaved by using a block de-interleaver 330. Thus, the output data of the block de-interleaver 330 is used for the Viterbi decoder 334 to decode the encoded data and to produce the information data bits at 223.4375 Mbps.

Page 11, in the detailed description section, the second paragraph (extends to page 12), replace with the following new paragraph:

--- Referring to FIG. 5 is a frequency response (dBm) 510 and impulse response 520 of digital FIR lowpass-shaping transmitter and/or receiver filter 500 based on the transmitter spectrum mask 420 in FIG. 4 for the use in each channel according to one embodiment. The result of designing the digital FIR lowpass-shaping filter 520 does meet the requirements of the

transmitter spectrum mask 420 of the outdoor power spectrum density 400 as defined in FIG. 4. The sampling frequency rate F_s of this filter is 2 GHz. This impulse response 520 of the digital FIR lowpass-shaping filter is an [[odd]] even coefficient symmetric about h[0] at n = 0 with a total of 83 filter coefficients. Table 2 lists all the filter coefficients of the digital FIR lowpass-shaping filter.

Page 13, in the detailed description section, the first paragraph, replace with the following new paragraph:

The implementation output *y[n]* of the digital FIR lowpass-shaping filter with 83 [[odd]] even symmetric coefficients can be expressed as,

$$y[n] = \sum_{k=0}^{82} h[n]x[n-k], \qquad (7)$$

where *h[n]* is a set of the digital FIR lowpass-shaping filter coefficients as shown in Table 2 and *x[n]* is the digital input signal. Since the digital FIR lowpass-shaping filter 520 is [[odd]] even symmetric coefficients, the above equation (7) can be rewritten as

$$y[n] = \sum_{k=0}^{40} h[n](x[n-k] + x[n-82+k]) + h[42]x[n-42]. \qquad (8)$$

The equation (8) can be implemented with saving half taps of the computation. The computation complexity of implementing this digital FIR lowpass-shaping filter in equation (8) is 42 multiplications and 82 additions.

Page 14, in the detailed description section, Table 3, replace with the following new table:

<u>Table 3</u>

Label of the channel frequency spectrums	Center Frequency (GHz)	Lower Frequency (GHz)	Upper Frequency (GHz)	Frequency Bandwidth (MHz)
[[962A]] <u>620A</u>	3.45	3.125	3.775	650
[[962B]] <u>620B</u>	4.10	3.775	4.425	650
[[962C]] <u>620C</u>	4.75	4.425	5.075	650
[[962D]] <u>620D</u>	5.40	5.075	5.725	650
[[962E]] <u>620E</u>	6.05	5.725	6.375	650
[[962F]] <u>620F</u>	6.70	6.375	7.025	650
[[962G]] <u>620G</u>	7.35	7.025	7.675	650
[[962H]] <u>620H</u>	8.00	7.675	8.325	650
[[962I]] <u>620I</u>	8.65	8.325	8.975	650
[[962J]] <u>620J</u>	9.30	8.975	9.625	650
[[962K]] <u>620K</u>	9.95	9.625	10.275	650

Page 14, in the detailed description section, the second paragraph, replace with the following new paragraph:

--- In order to reduce the number of filter taps for the digital FIR lowpass shaping transmitter filter, an efficient design method 700 of the two cascaded filters may be used as shown in FIG 7. The first filter 710 is referred to as the digital multiband lowpass-shaping filter. The second filter 720 is called [[as]] the digital rejected lowpass filter. The combinations of the first digital FIR lowpass-shaping filter 710 and the second digital rejected lowpass filter 720 meet the frequency spectrum requirement of the transmitter spectrum mark 420 of the outdoor power spectrum density 400 as shown in FIG. 4.

Page 15, in the detailed description section, the second paragraph, replace with the following new paragraph:

--- Referring to FIG. 9 is a frequency response (dBm) 910 and impulse response 920 of the digital enlarged lowpass-shaping transmitter 900 based on the enlarged transmitter spectrum mask 820 of the power spectrum density 800 in FIG. 8 according to one embodiment. This impulse response 920 of the digital enlarged lowpass-shaping filter is an [[odd]] <u>even coefficient</u> symmetric <u>about h[0] at n = 0</u> with a total of 51 filter coefficients. Table 4 lists all the enlarged filter coefficients.

Page 16, in the detailed description section, the second paragraph (extends to page 17), replace with the following new paragraph:

--- Referring to FIG. 10 is a frequency response (dBm) 1010 of the digital multiband lowpass-shaping transmitter filter according to some embodiments. The center frequency band shaping of the frequency response 1010 meets the requirement <u>of</u> the transmitter spectrum mark 420 of the power spectrum density 400 as shown in FIG. 4. This digital multiband lowpass-shaping filter has a ~~symmetry~~ <u>symmetric</u> image band that is created by inserting one zero [[into]] in [[the]] between [[of]] every two filter coefficients of the digital enlarged lowpass shaping filter. In other words, the digital multiband lowpass-shaping filter 1010 has 51 filter taps and 50 zeros. ~~Since the~~ <u>The</u> filter does not need to implement the zero coefficients. As a result, the computation complexity of implementing this digital multiband lowpass-shaping filter 1010 is 26 multiplications and 50 additions.

Page 19, in the detailed description section, the first paragraph, replace with the following new paragraph:

--- Referring to FIG. 15 is an output of multichannel frequency spectrums 1500 with multi-carriers including 10- transmitter channel spectrums

152064A-1520C, 1520E-1520K, along with the outdoor FCC emission limitation 610 according to some embodiments. ~~There does not exist the~~ The fourth channel does not exist with frequency range from 5.075 GHz to 5.725 GHz in the frequency spectrums 1500. By [[no]] not transmitting the fourth channel, the interference between the outdoor handheld UWB communication devices and WLAN 802.11a lower band can be avoided since the WLAN 802.11a lower band is in the frequency range from 5.15 GHz to 5.35 GHz, thereby resulting in coexistences.

Page 19, in the detailed description section, the second paragraph, replace with the following new paragraph:

--- Referring to FIG. 16 is an output of multichannel frequency spectrums 1600 with multi-carriers including 10 transmitter channel spectrums 1620A-1620D, 1620F-1620K, along with the outdoor FCC emission limitation 610 according to some embodiments. There is not [[the]] fifth channel with frequency range from 5.725 GHz to 6.375 GHz in the frequency spectrums 1600. By [[no]] not transmitting the fifth channel, the interference between the outdoors handheld UWB communication devices and WLAN 802.11a upper band can be eliminated. This is because the WLAN 802.11a upper band is in the frequency range from 5.725 GHz to 5.825 GHz, thereby resulting in UWB and WLAN 802.11a coexistences.

Page 19, in the detailed description section, the third paragraph (extends to page 20), replace with the following new paragraph:

--- Now referring to FIG. 17 is an output of multichannel frequency spectrums 1700 with multi-carriers including 9-transmitter channel spectrums 1720A-1720C, 1720F-1720K, along with the outdoor FCC emission limitation 610 according to some embodiments. The frequency spectrum 1700 does not include the fourth and fifth channels with frequency range from 5.075 GHz to 6.375 GHz. By [[no]] not transmitting

the fourth and fifth channels, the interference between the outdoors handheld UWB communication devices and WLAN 802.11a lower and upper bands can be avoided. This is because the WLAN 802.11a lower and upper bands are in the frequency ranges from 5.150 GHz to 5.350 GHz and from 5.725 GHz to 5.825 GHz, respectively. As a result, the interference can be avoided between the outdoor handheld UWB and WLAN 802.11a by no transmitting the fourth and fifth channels of multichannel filter-based outdoor handheld UWB communication device.